

# Interferometry at JPL

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# Interferometry Projects

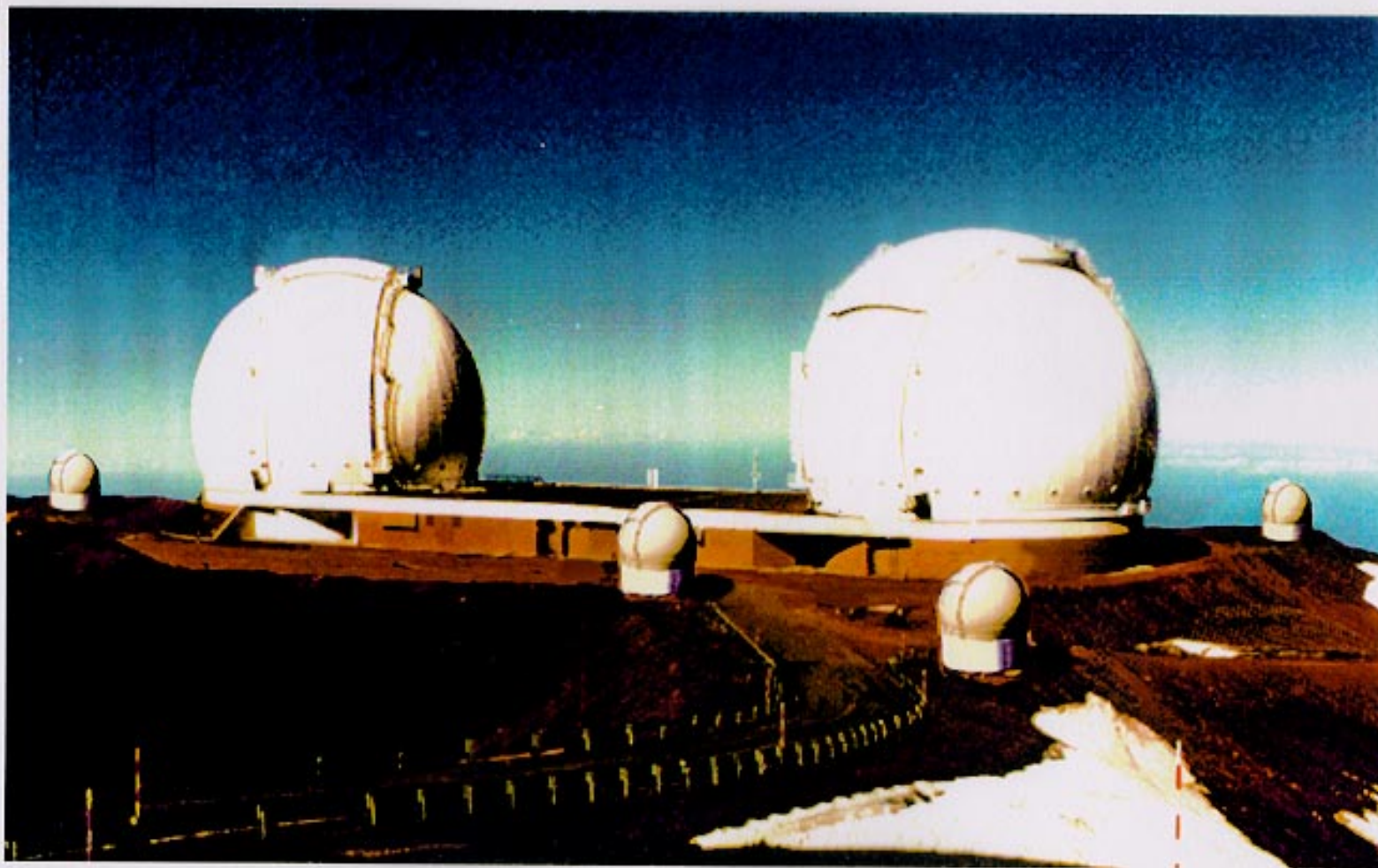
- Testbeds
  - Palomar Testbed Interferometer
  - SIM system testbed(s)
  - DS-3 Separated Spacecraft Interferometer flight demo
- Observatories
  - Keck Interferometer
  - SIM
  - Terrestrial Planet Finder

# Palomar Testbed Interferometer



- Located at Palomar Observatory, 110 m baseline IR (2.2 $\mu$ m) interferometer
- Testbed for Keck project, first fringe July 95
- To demonstrate narrow angle astrometry to  $\sim 60$   $\mu$ as (300  $\mu$ rad) and phase reference interferometry

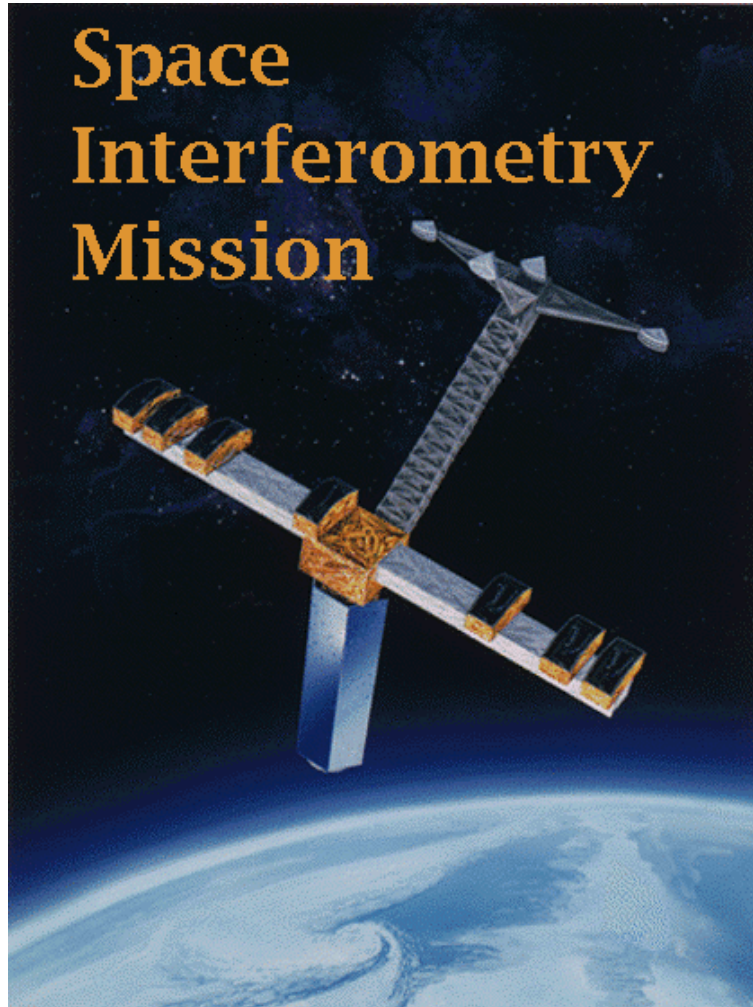
## Configuration showing 2 meter outrigger telescopes



# Keck Interferometer Overview

- *Science objectives*
  - *Exo-zodiacal emission at 10  $\mu\text{m}$  around nearby stars.*
  - *Direct detection of warm, giant planets and brown dwarfs.*
  - *Astrometric detection of Uranus-sized planets to 20 pc.*
  - *Imaging of protoplanetary discs*
- *Measurements*
  - *Synthesis imaging with 3 mas resolution @ 2  $\mu\text{m}$ .*
  - *Astrometric accuracy of 10  $\mu\text{as}$ .*
    - *22 mag @ 2  $\mu\text{m}$  in 500 sec.*
  - *Starlight nulling for exo-zodi (down to 10 solar zodi)*
- *Approach*
  - *Combine the two Keck telescopes as an interferometer*
  - *Add four, two-meter outrigger telescopes for imaging and astrometry.*

# Space Interferometry Mission

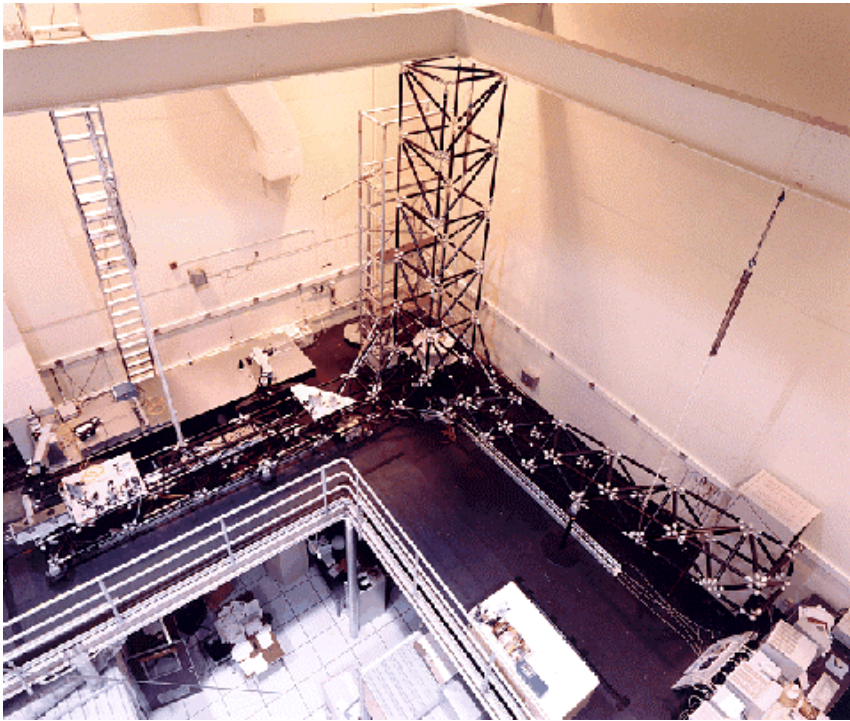


- 4  $\mu$ as global astrometry
- 10 m deployed baseline
- 1  $\mu$ as local astrometry
- Synthetic aperture imaging and nulling
- Cosmic distance scale (age)
- Planet search
- Galactic rotation (dark matter)
- Structure of AGNs

# Technical Challenges

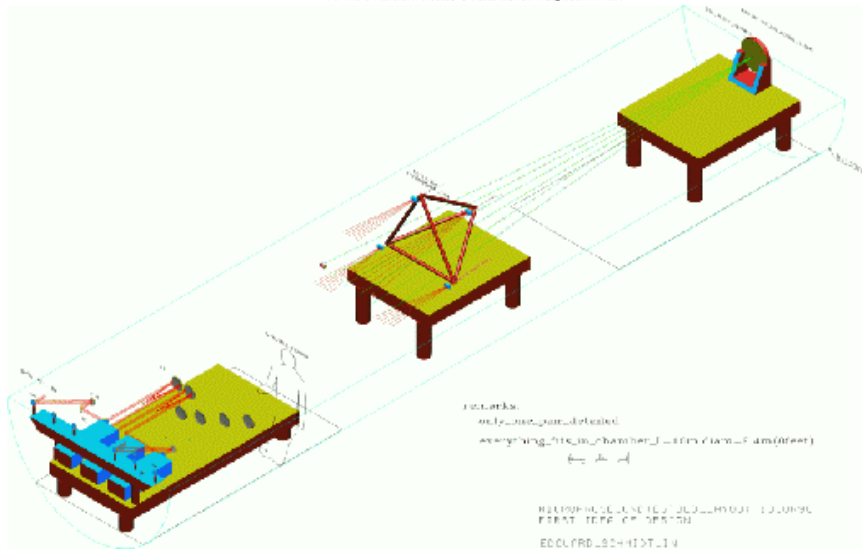
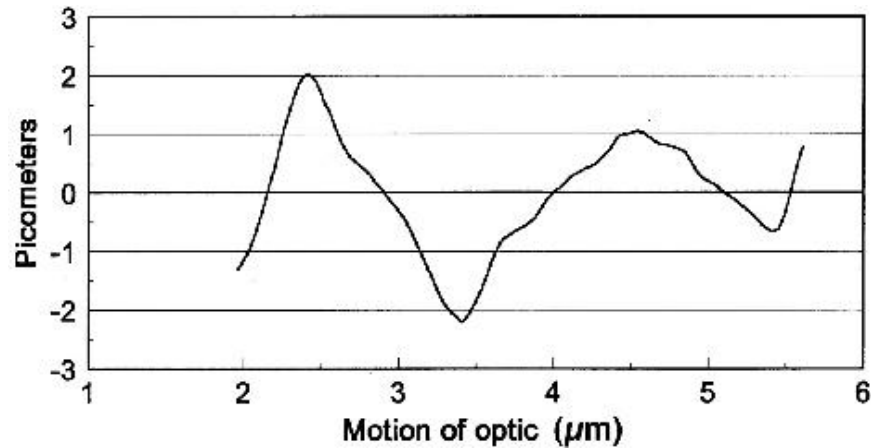
- Large deployed structure in space with (10's) nanometer stability of optical paths
- In order to perform 4 $\mu$ as astrometry, we must measure the position of the optics with very high accuracy,  $\sim 200$ picometer (pm).

# Vibration Suppression

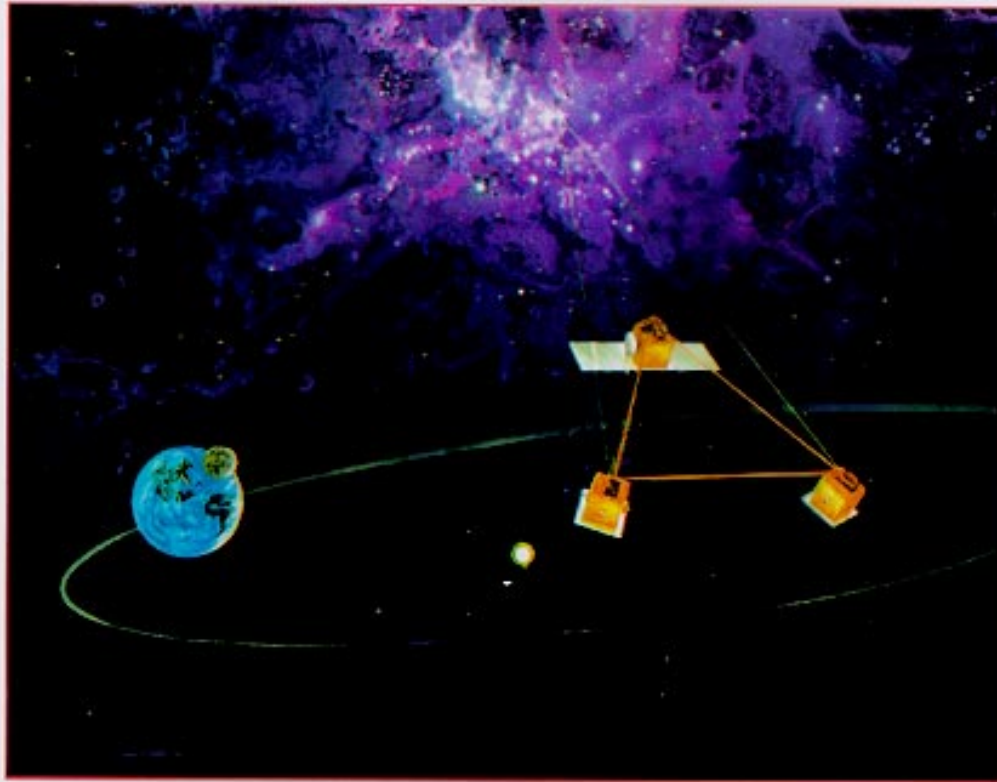


- Testbed ~7m flexible truss structure, with simulated on board noise sources
- Combination of active vibration isolation and active optical control reduces ambient noise from a few  $\mu\text{m}$  to  $\sim 8\text{ nm}$ .
- Future, reduce projected on orbit optical path jitter to  $\sim 1\text{ nm}$

# Picometrology



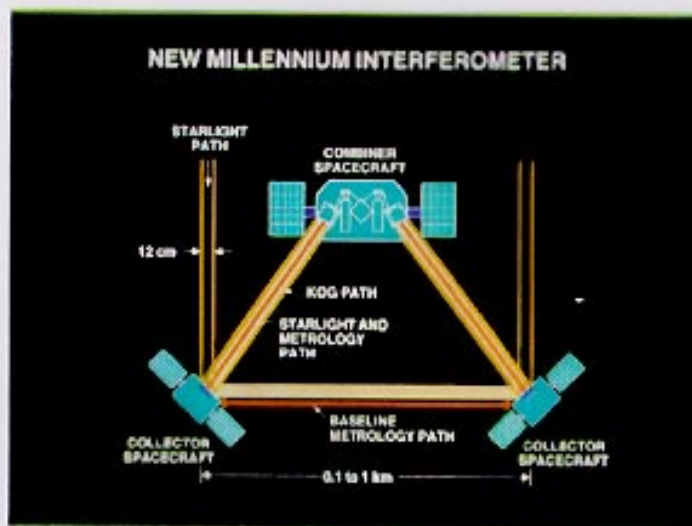
- 1Dimensional laser metrology at picometer levels
- Design and construction of microarcsec metrology testbed underway
  - 3D optical truss with total system error < 200pm (goal)



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New Millennium DS-3

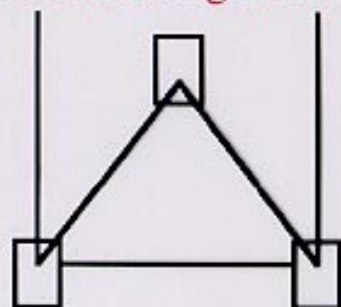
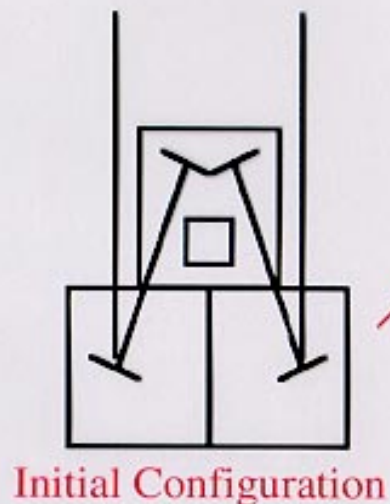
## DS-3 Configuration



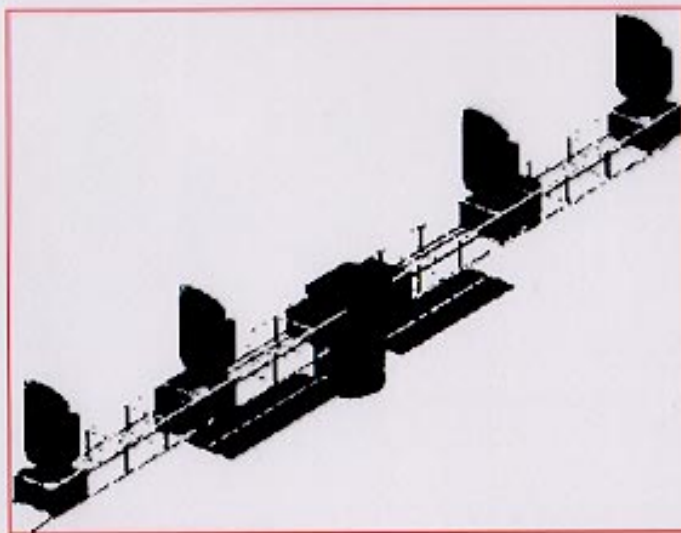
### Baseline

- 3 spacecraft, 2 identical collectors, one combiner
- Inter S/C metrology for:
  - relative attitude 50 mas
  - relative distance 10 nm
- Constellation rotation with optical gyro

## DS-3 Experiment Summary



- *S/C bolted together as a connected link interferometer*
  - *Automated fringe acquisition and tracking*
    - *FAST substitute*
  - *Automatic alignment after launch*
  - *More complex sequences (retargeting (2), rotational synthesis)*



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## Terrestrial Planet Finder

*Search for Habitable Planets around other stars in the  
solar neighborhood*

## Scientific Objectives

- *Detect and characterize terrestrial planets around nearby stars*
  - *Make family portraits for ~1,000 stars out to ~50 light years*
    - *Brightness, temperature, orbital distance of planets*
    - *Infer size and mass*
  - *Characterize atmospheres of ~100 brightest planets*
    - *Look in 7-17  $\mu\text{m}$  region for  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ ,  $\text{O}_3$ ,  $\text{CH}_4$*
    - *Infer habitability from composition and physical conditions*
- *Carry out other astrophysical investigations*
  - *High sensitivity, high spatial resolution in IR*

